ADMINISTRATIVE INFORMATION

1. **Project Name:** High-Intensity Plasma Glass Melter—GO13093

2. **Lead Organization:** Plasmelt Glass Technologies, LLC
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3. **Principal Investigator:** Michael Weinstein
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4. **Project Partners:** J. Ronald Gonterman – Plasmelt - Program Director
AGY – Cost share partner—Steve Allen
JM – Cost share partner – Aaron Huber
Subcontractors:
   - James Hayward—Independent Consultant - Melting
   - Gabriel Tincher—N.Sight Partners - Marketing Studies
   - Oleg Prokhorenko—Lab of Glass Properties – Modeling
   - Dr. Scott Parker—University of Colorado - Plasma Physicist

5. **Date Project Initiated:** 7/28/03

6. **Expected Completion Date:** 7/27/06 (revised based on DOE approval for project extension)

PROJECT RATIONALE AND STRATEGY

7. **Project Objective:** Develop a 500 lb/hr transferred-arc plasma melting process that can produce high quality glass suitable for processing into a commercial article.

8. **Technical Barrier(s) Being Addressed:** The preliminary work on glass melting via plasma that was previously conducted by JM showed that good energy efficiency is possible, up to throughputs of 1000 #/hr. However, glass quality was not addressed. Torch life and process stability were the primary technical barriers that were identified from this earlier work. This project is aimed at developing improved torch designs and a stable set of operating conditions as well as the quantitative understanding of the relationship between the operational parameters of the plasma melting system and the effect on glass quality, energy efficiency, and environmental impact.

9. **Project Pathway:** Plasmelt has constructed a melting facility that is capable of performing experimental research on melting energy efficiency and environmental impact as well as the glass quality issue that was not previously addressed by the JM work. Poor glass quality is one very key issue that will prevent the adoption of plasma melting technology within the glass industry. Therefore, Plasmelt has developed a melting process with E-glass as the model composition in which glass nuggets can be produced. Glass nuggets have been re-melted and processed in a marble re-melt fiber forming position and the glass quality of the fibers has been assessed. These glassfiber quality measurements have formed a link between the plasma-melting process variables and the resultant glass fiber quality, energy efficiency, and environmental impact. To the best of our knowledge, this fiberizing experiment using plasma-melted glass has never been run before. The fiberizing trials have provided key glass quality assessments that should be useful in convincing other segments of the glass industry that plasma

melting has good potential in high quality applications.

Plasma technology is being developed that can routinely produce several hundred pounds of glass on a continuous basis. This process is now capable of continuously operating for many hours in a "hands-off" mode.

10. Critical Technical Metrics:

Technical metrics—Baseline vs. Project Objectives

- Length of runtime of a stable glass melting operation before torches must be replaced (i.e. torch life in hours). Several minutes to a few hours were demonstrated by JM. The objective of this project is to demonstrate 100 hours of routine torch life without interruption.
- Current energy consumption within the glass industry varies widely with segment and type of technology, but generally ranges from 5 to 12 MM BTU/ton of glass melted. The objective of this project is to demonstrate 4.1 MM BTU/ton of glass or less.
- Existing fiber forming technology with good glass quality routinely reaches 0.5 breaks per bushing per hour. With plasma-melted glass, our goal is to achieve at least one break per bushing per hour or better.

PROJECT PLANS AND PROGRESS

11. Past Accomplishments:

In the first 24 months of the program, we completed the construction phase and undertook the process development research. Accomplishments to date include the following:

- Within 5 months of project startup, completed the construction of a plasma-based glass-melting research lab in Boulder, CO
- Designed, fabricated and installed plasma melting system and accessory systems
- Developed a process to routinely melt glass with a wide range of compositions
- Produced hundreds of glass samples under various process conditions for glass quality analyses
- Completed first year under budget meeting all Year 1 Milestones and project requirements, except the 500 #/hr objective
- Completed second year on budget and met all milestones, with the exception of the demonstration of a stable 500 #/hr process. Did demonstrate 50 to 350 #/hr
- Developed a low maintenance-cost standard 5/8" torch design that has been used for all plasma melting work in the past year and is still performing well
- Obtained Exemption from Colorado Dept. of Health & Environmental Control to allow the research work to be conducted in Boulder, Colorado
- Completed market study to determine the size of the market for high intensity plasma melting glass technology
- Developed forming technology to produce a lower cost simulated marble (nuggets) that were suitable for use in fiberizing trials
- Successfully conducted fiberizing trials at AGY's Huntingdon, PA commercial facility and demonstrated good fiber properties for coarser filaments in the 10 micron or greater range
- Conducted exploratory melting trials on wide ranging glass compositions: E-glass, high strength fiberglass (S-glass), lighting tube glass, frit glasses, & silica
- Demonstrated a 300 to 350 #/hr E-glass melting process with energy efficiencies of ~ 1.1 KWH/# vs. a goal of 0.6 KWH/#
- Rapidly improved initial torch lives of <10 minutes before failures to current process with >25 hours

- Routinely conducting hands-off plasma-melting operations as evidence that the entire plasma-melter process is reasonably stable
- Developed understanding of the technology relationship between molybdenum and glass interactions to minimize detrimental black glass problems
- Have defined molybdenum as a key materials limitation in the current plasma melter design
- Successfully demonstrated a fiberglass scrap melting process using dry-chop fibers

12. Future Plans:

- Complete the environmental assessment for the high throughput condition — October 31, 2005
- Complete the melting survey of generic glass compositions — December 31, 2005
- Complete the high throughput trials to define the upper throughput limit — October 31, 2005
- Optimize energy efficiency, torch design and operation — October 31, 2005
- Final Report — July 27, 2006

13. Project Changes:

1. The original project proposal outlined a milestone of producing marbles in the plasma lab that could be shipped to a second location for subsequent fiberizing trials. These trials were deemed crucial to investigating the glass quality of plasma-melted glass.

After this project had been underway for several months and a Plasmelt design team had finished their recommended design for marble fabrication equipment, it became obvious that the cost of installing this design ($500,000 of capital) could not be covered by this project. Due to this high cost of installing marble production facilities in the Boulder Lab, another glass form was substituted for marbles—glass nuggets. Hand molds were fabricated to allow the production of these unique glass nuggets. This change from marbles to nuggets allowed the project to avoid approximately $500,000 in capital equipment but did not sacrifice the project objective to conduct fiberizing trials. Successful fiberizing trials were subsequently conducted with AGY using glass nuggets.

2. Our ability to demonstrate 500 #/hr of good quality glass from a stable process has proven to be more difficult than anticipated. Many barriers have been identified and overcome. A few remain.

In recognition that we would complete many, but not all, of the original objectives of the project, we elected to petition DOE for additional funds and additional time to complete the project. An extension was granted by DOE to continue the project against the original objectives before the new extension termination date of 7/27/06.

14. Commercialization Potential, Plans, and Activities:

In order to understand better the niches within the glass industry where the attributes of plasma melting technology would have the greatest benefits, a market study was performed by one of our subcontractors. The results of this study were used to form the foundation for a Plasmelt business plan, aimed at propagating this plasma melting technology within the glass industry. Preliminary findings of this market survey suggest that this technology will find the best acceptance within the specialty glass segment of the glass industry. During the past several months, we have pursued activities to support the future Plasmelt business:

- aggressively sought out individual companies to promote actual melting evaluations in the Plasmelt Boulder Lab using glasses that are of interest to specific companies

- investigated pilot facility installations at one or more cost share partners to quickly follow onto the termination of this DOE sponsored program
- networked with key personnel in the British Glass Plasma Glass Melter Project to understand their business objectives and identify any opportunities
- performed melting evaluations for various companies of their own glass compositions. A total of five (5) different companies have melted materials in our lab. Work with all of these companies looked promising and additional work is being completed.
- held business negotiations with companies to expand existing business relationships
- present technical papers at selected meetings of interest to glass companies

PLANS

- Continue to modify the plasma melter to improve its performance in the three key areas: environmental impact, glass quality, and operating costs
- Document scrap glass reclaim accomplishments. Scrap recycling can be a large additional market segment using the same technology.
- Complete negotiations with at least one company to develop a pilot plasma melter
- Continue to seek out specialty glass companies to solicit plasma melting evaluations of their candidate glass compositions
- Seek out potential Joint Venture Partners

15. Patents, Publications, Presentations:

- Advances in the Melting of Glass Conference – Rochester, NY, July, 2003, High Intensity Plasma Glass Melting Project plans and background was presented.
- NREEL Project Review, Golden, CO, September, 2003, Presentation of Program Status of High Intensity Plasma Glass Melter.
- NREEL Project Review, Crystal City, July, 2004, Presentation of Program Status of High Intensity Plasma Glass Melter

16. Budget History and Projection, $000:

FY	ITP	Industry (note cash, in-kind, labor)	Other
2003	~$600	~$257	
2004	~$475	~$132	
2005	~$237	~$174	
TOTAL	**~$1,312**	**~$563**	